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Materials and structural aspects of solid oxide electrochemical cells for conversion of electricity to hydrocarbons and reverse

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Regarding invited presentation at the 9th Liège Conference on Materials for Advanced Power Engineering

<u>Title</u>: Materials and structural aspects of solid oxide electrochemical cells for conversion of electricity to hydrocarbons and reverse

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<u>Abstract</u>: The solid oxide cell (SOC) is an electrochemical cell that may be applied as fuel cell (SOFC) as electrolysis cell (SOEC), i.e. this kind of electrochemical cell is fully reversible. The SOC is operated at temperatures in the range from 500 to 1000 °C. SOFC can produce electricity by converting CO as well as H_2 (and other energy rich gases) because of the elevated temperature. Likewise, the SOFC reaction products, CO_2 and H_2O, can be converted back to syngas (H_2 + CO), if electric energy is supplied to the cell, which then operates in electrolysis mode. The latter opens the possibility of producing CO_2 neutral synthetic hydrocarbons of almost all kinds through well-known catalytic processes. These synthetic hydrocarbons include gasoline and diesel. CO_2 may be capture from atmospheric air.

This has in principle been known for several decades. Furthermore, during the latest 1 – 2 decades the SOFC has been developed to a level that it is near commercialisation, and during the latest few year this tremendously improved cell type has been tested as electrolyser cell to some extent.

Several papers have indicated that the performance and durability of the SOEC in particular is low. As it will be demonstrated in this presentation, this is, however, extremely dependent on the precise composition of the materials used in the cell material and on the detailed structure of the composite electrodes of the cell. The structure is very important from the macroscopic level and on all levels right to the atomic structure and chemical composition of the surfaces and interfaces. The composition of the region around the three phase boundary (TPB) line, at which the gaseous reactants, the ion conducting electrolyte and the electron conducting electrode material meet each other, is of particular importance. Further, the importance of impurities that can accumulate at the TPB is outlined.

Finally, the presentation describes the SOC state of the art with respect to performance and durability of the cells in both SOFC and SOEC mode. The electrode reaction mechanisms and their degradation are briefly presented.